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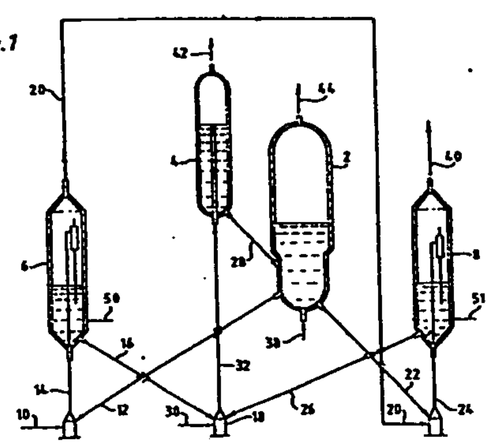
(54) **Dual riser fluid catalytic cracking process.**

(57) An improved fluid catalytic cracking process for achieving high conversions of low quality feedstocks (containing metal contaminants, basic nitrogen and/or coke precursors) at relatively low severities, by passing the feedstock in series through a dual riser reactor system having a common catalyst stripper and regenerator, in contact with freshly regenerated catalyst which is passed in parallel from the regenerator through each of the riser reactors.

FIG.1



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DUAL RISER FLUID CATALYTIC CRACKING PROCESS

This invention relates to a dual riser fluid catalytic cracking process wherein a low quality feedstock is passed through the risers in series; the feedstock is in contact with freshly regenerated catalyst which is passed through the risers in parallel.

Catalytic cracking is the major molecular weight reduction process employed in petroleum refining for manufacturing gasoline as fuels. Business incentives require the processing of heavier, low-quality feedstocks, lower output of residual products and increased energy efficiencies while meeting more stringent environmental constraints. Current catalysts require high temperature and short contact time riser reactors to obtain the full benefits of the process, i.e., highest selectivity to gasoline at highest conversion yields. These catalysts require high temperature regeneration (CO combustion). This approach also allows for catalysts with greater metals tolerance, octane enhancement and SO_x capture.

In the catalytic cracking of low quality hydrocarbon feedstocks, metal contaminants such as nickel, vanadium and iron are deposited on the catalyst and reduce its effectiveness in converting the feedstock to lower boiling components such as gasoline. One way of at least partially overcoming these adverse effects is by treating the catalyst with agents which reduce the ability of contaminants on the catalyst to adversely affect the cracking process. For example, in U.S. 4.326,990 selected treating agents are added to the feedstock; in the reactor these agents are deposited on the catalyst.

The effectiveness of a cracking catalyst is also reduced by temporary catalyst poisons such as basic nitrogen components and high boiling coke precursors, which reduce the ability of the

catalyst to achieve high conversion of the feed without excessive cracking to undesirable light hydrocarbons.

In catalytic cracking many different reactor configurations have been proposed, all claiming to have certain advantages. For example, in U.S. Patent 4,090,949 a dual riser reactor catalytic cracking system is disclosed, having a common catalyst regenerator supplying freshly regenerated catalyst to each riser, whilst fresh gas oil feed is contacted with freshly regenerated catalyst in the first riser and light C_2-C_5 olefins are contacted with freshly regenerated catalyst in the second riser. In another dual riser catalytic cracking system, as disclosed in U.S. Patent 3,748,251 charge stock is passed into a reaction zone together with a catalyst composition comprising two cracking components, part of which is ZSM-5, hydrocarbons are withdrawn from the reaction zone, unreacted hydrocarbon charge is separated and introduced into a second reaction zone together with said catalyst.

It is an object of this invention to remove from the feedstock essentially all of the temporary catalyst poisons, such as basic nitrogen constituents and coke precursors, and metal contaminants at relatively low conversions, e.g., 15 to 25% in the first reactor, thereby requiring low severity, i.e., lower catalyst/oil ratios.

It is another object of the invention to catalytically crack the total product from the first reactor to a high conversion at low severity over freshly regenerated catalyst.

It is a further object of the invention that the total severity required for these two separate subsequent steps of cracking will be significantly lower than that required if the same total conversion were achieved in a single step.

It is a still further object of the invention to use a common catalyst inventory to remove metal contaminants comprising nickel and/or vanadium and temporary catalyst poisons and to achieve a high conversion of low quality feedstocks.

This invention relates to an improved fluid catalytic cracking process for low quality hydrocarbon feedstocks, said

process having a dual riser reactor system with a common catalyst stripper and regenerator, which comprises passing said feedstock into a first riser reactor zone, and contacting said feedstock with freshly regenerated fluid cracking catalyst under relatively low severity reaction conditions suitable for relatively low conversion of feedstocks to lower boiling components while simultaneously reducing metal contaminants and temporary catalyst poisons contained therein; separating first riser reaction products from catalyst in a first separation zone and passing a mixture of relatively clean unconverted feedstock and reaction products from said separation zone into a second riser reactor zone, and contacting the mixture with freshly regenerated fluid cracking catalyst under relatively low severity reaction conditions suitable for relatively high conversion of feedstocks to lower boiling components; separating second riser reaction products from catalyst in a second separation zone; passing partially deactivated catalyst, containing metal contaminants, coke and unreacted hydrocarbons, from both separation zones to a catalyst stripper and contacting said catalyst with steam under conditions to remove a substantial portion of said unreacted and/or adsorbed hydrocarbons; passing catalyst from the stripper to a regenerator and contacting said catalyst with air under reaction conditions suitable to combust coke and unconverted hydrocarbons; separating combustion products from regenerated catalyst as flue gas; circulating freshly regenerated catalyst to both risers for contacting fresh feedstock and said mixture of unconverted feedstock and reaction products respectively; and recovering cracked products from the second separation zone.

The process according to the invention can be suitably applied to low quality hydrocarbon feedstocks containing metal contaminants comprising nickel and/or vanadium in amounts from about 1 to 100 parts per million by weight (ppmw). It can also be suitably applied to hydrocarbon feedstocks containing from about 300 to 8000 ppmw of basic nitrogen. Furthermore, the process can

be suitably applied to hydrocarbon feedstocks containing from about 0.5 to 10 %w of coke precursors, determined as Ramsbottom Carbon Residue. The process according to the invention is suitably carried out using well-known catalysts, such as commercially available cracking catalysts and, in particular X or Y type zeolites contained in a silica-alumina matrix.

The process according to the present invention, which is carried out in a two reactor-one regenerator system with the feed in series flow and the catalyst in parallel flow, is illustrated in Fig. 1.

In the dual riser catalytic cracking process shown in Fig. 1, the system includes primarily a catalyst regeneration zone 2, a catalyst stripper zone 4, a first catalyst separation zone 6, and a second catalyst separation zone 8.

Fresh feedstock is introduced into the system via line 10, where it is contacted with freshly regenerated catalyst from regenerator 2 via line 12. The feedstock and catalyst are passed under suitable reaction conditions upwardly through the first riser (line 14) wherein the feedstock is partially converted to lower boiling components. The mixture of unconverted feed, conversion products and catalyst is then passed into a first separation zone 6, wherein catalyst and gaseous hydrocarbons are separated. An optional embodiment of the invention is to add prestripping steam to separation zone 6 via line 50. The separated catalyst, which is partially deactivated, is passed via line 16 to a riser pot 18, where it is contacted by steam introduced via line 30 and lifted via line 32 to catalyst stripper 4.

The gaseous hydrocarbons from separation zone 6 are passed via line 20 to the second riser (line 24) where they are contacted with freshly regenerated catalyst from regenerator 2 via line 22 and passed under suitable reaction conditions upwardly through said second riser, wherein a substantial portion of the unconverted feedstock from catalyst separation zone 6 is converted to lower boiling components. The mixture of unconverted feed,

conversion products and catalyst is then passed into a second separation zone 8, wherein catalyst and gaseous hydrocarbons are separated.. An optional embodiment of the invention is to add prestripping steam to separation zone 8 via line 51. The separated catalyst, which is partially deactivated, is passed via line 26 to a riser pot 18, where it is combined with catalyst from separation zone 6, and is contacted by steam introduced via line 30 and lifted via line 32 to catalyst stripper 4.

The gaseous hydrocarbons from catalyst separation zone 8 are passed via line 40 to a fractionator where suitable cracked products are recovered.

The hydrocarbons and gases stripped from the catalyst in stripper 4 are passed via line 42 to the same or another fractionator for separation of water and recovery of products.

The stripped catalyst from stripper 4 is passed via line 28 to a regeneration zone 2, where it is contacted with air introduced via line 38. The partially deactived catalyst is regenerated under conditions suitable to remove coke and basic nitrogen compounds. Flue gases from the regeneration zone are vented via line 44. Freshly regenerated catalyst is circulated to the first and the second riser via lines 12 and 22, respectively, and the process is continued.

EXAMPLE

This example illustrates the benefits to be realized by removing temporary catalyst poisons from low quality catalytic cracking feedstocks.

Two feedstocks, A (light flashed distillate) and B (commercial FCCU feed), were deresined in the laboratory. Properties of the total and deresined feedstocks are shown in Table 1. Feedstock A was a fairly high quality, clean light flashed distillate and was included for comparison. Feedstock B was a low quality feed, such as those suitable for the process of the invention, which contained a significant amount of basic nitrogen compounds.

The deresining step consists of mixing the feedstocks with isooctane and passing the mixture over attapulgas clay. Other suitable clays for this purpose include Fuller's Earth and Florex-S. The total resins, including the basic nitrogen compounds, are adsorbed on the clay.

Feedstocks A and B, both before and after deresining, were then tested in a micro activity test (MAT) unit.

The MAT used in these studies and the operating procedure were similar to those described in ASTM D 3907-80. Briefly about 5.0 grams of catalyst are contained in a small diameter reactor (ASTM specifies 15.6 mm I.D.). The feed is passed over the catalyst for about 60 seconds. Immediately after the oil addition, nitrogen is introduced to strip the catalyst. Both a liquid and a gas are recovered as products. These are conveniently analyzed by conventional chromatographic equipment.

The results of the micro activity tests are plotted in Figs. 2A-2C (feedstock A) and 3A-3C (feedstock B). In all graphs, the straight lines relate to experiments carried out with total feed and the dotted lines relate to experiments carried out with deresined feedstock.

In Figures 2A and 3A the conversions of total feed and deresined feedstock, respectively into 232 °C material, expressed as 100-%w of 232 °C$^+$ material are plotted (on the horizontal axis) against the coke production in %w. In Figures 2B and 3B the conversions (as expressed for Figures 2A and 3 A) are plotted against the yield of the C_5-232 °C fraction. Finally, in Figures 2C and 3C, respectively, the weight hourly space velocities are plotted (on the horizontal axis) against the conversions of total feed and deresined feedstock, respectively, as expressed hereinbefore. It will be clear from the Figures 3A-3C in comparison with Figures 2A-2C that the improvement in cracking characterstics (less refractory, more gasoline and less coke) following deresining is significantly greater for Feedstock B than for Feedstock A.

Cracking Feedstock B to a low conversion in a first riser reactor will achieve essentially the same benefits as the deresining treatment. The total product from this low conversion first reactor can then be easily cracked at low severity to a high conversion in a second riser reactor.

TABLE 1

Properties of Total and Deresined Feeds

	Feedstock A		Feedstock B	
	Total Feed	Deresined Oil (1)	Total Feed	Deresined Oil (1)
API Gravity	24.7	25.6	22.7	24.7
Mol Weight	320	-	331	-
Basic N_2, %w	0.02	0.00	0.10	0.00
Composition %w				
Alkanes	22.4	23.4	10.1	11.2
Cyclo Alkanes	33.1	34.6	36.2	40.1
Mono Aromatics	16.9	16.6	18.1	17.9
Di Aromatics	19.4	19.2	23.4	23.7
Tri Aromatics	7.9	6.2	10.7	6.9
Tetra Aromatics	0.1	0.0	0.5	0.2
Basic N_2 Nuclei	0.2	0.0	1.0	0.0
	100.0	100.0	100.0	100.0

(1) 4.3 %w Resins Removed

(2) 9.8 %w Resins Removed

CLAIMS

1. An improved fluid catalytic cracking process for low quality hydrocarbon feedstocks, said process having a dual riser reactor system with a common catalyst stripper and regenerator, which comprises passing said feedstock into a first riser reactor zone and contacting said feedstock with freshly regenerated fluid cracking catalyst under relatively low severity reaction conditions suitable for relatively low conversion of feedstocks to lower boiling components while simultaneously reducing metal contaminants and temporary catalyst poisons contained therein; separating first riser reaction products from catalyst in a first separation zone and passing a mixture of relatively clean unconverted feedstock and reaction products from said separation zone into a second riser reactor zone and contacting the mixture with freshly regenerated fluid cracking catalyst under relatively low severity reaction conditions suitable for relatively high conversion of feedstocks to lower boiling components; separating second riser reaction products from catalyst in a second separation zone; passing partially deactivated catalyst, containing metal contaminants, coke and unreacted hydrocarbons from both separation zones to a catalyst stripper and contacting said catalyst with steam under conditions to remove a substantial portion of said unreacted and/or adsorbed hydrocarbons; passing catalyst from the stripper to a regenerator and contacting said catalyst with air under reaction conditions suitable to combust coke and unconverted hydrocarbons; separating combustion products from regenerated catalyst as flue gas; circulating freshly regenerated catalyst to both risers for contacting fresh feedstock and said mixture of unconverted feedstock and reaction products, respectively; and recovering cracked products from the second separation zone.

2. A process according to claim 1, wherein the feedstock contains from about 1 to 100 ppmw of metal contaminants comprising nickel and/or vanadium.

3. A process according to claim 1 or 2, wherein the feedstock contains from about 300 to 8000 ppmw of basic nitrogen.

4. A process according to any one of claims 1-3, wherein the feedstock contains from about 0.5 to 10 %w of coke precursors determined as Ramsbottom Carbon Residue.

5. A process according to any one of claims 1-4, wherein the conversion in the first riser is in the range of about 15 to 25 %w based on the feedstock.

6. A process according to any one of claims 1-5, wherein the conversion after the second riser is between about 55 and 80 %w, based on the fresh feedstock.

7. Catalytically cracked products, whenever obtained by a process according to one or more of the preceding claims.

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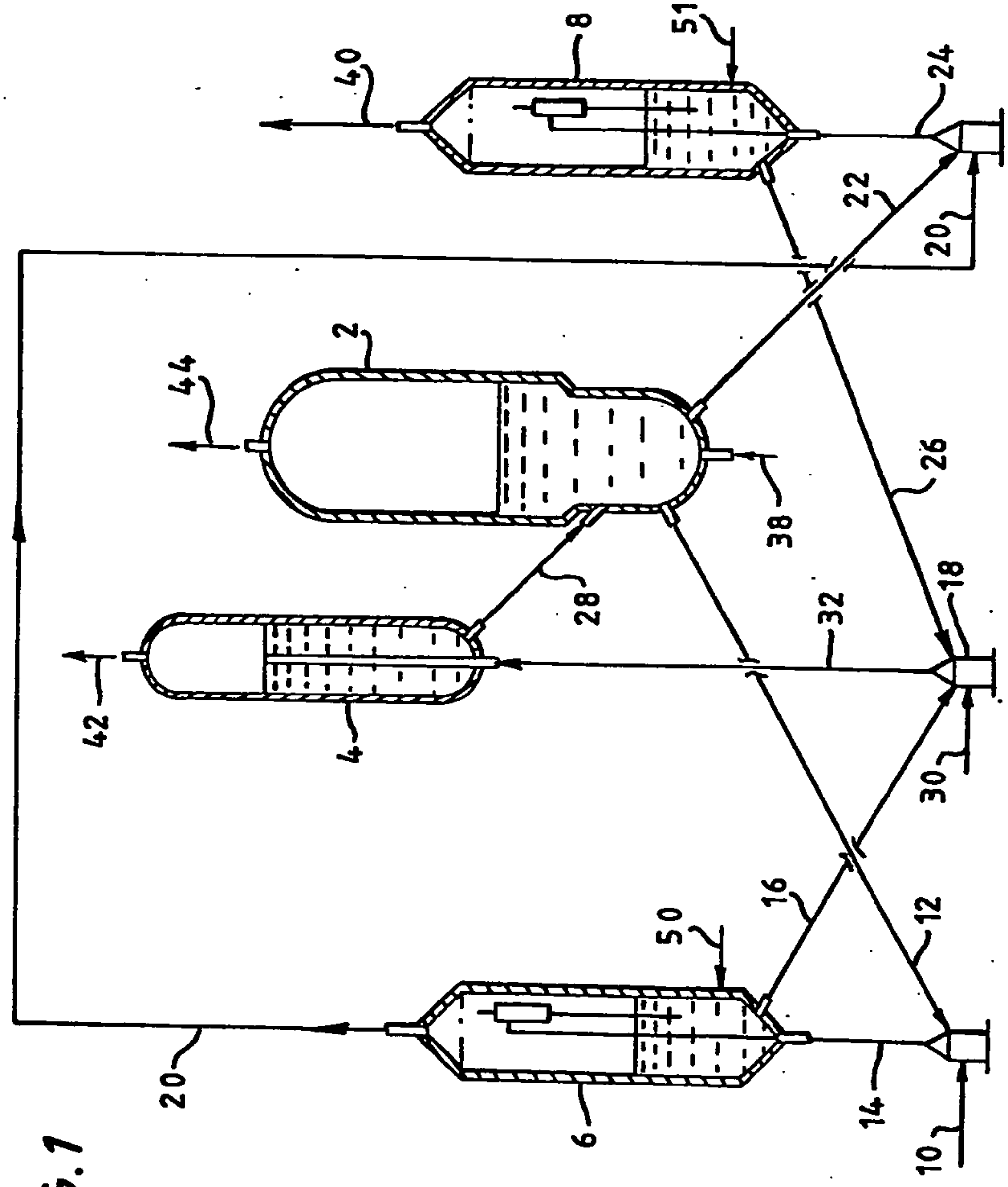

FIG.1

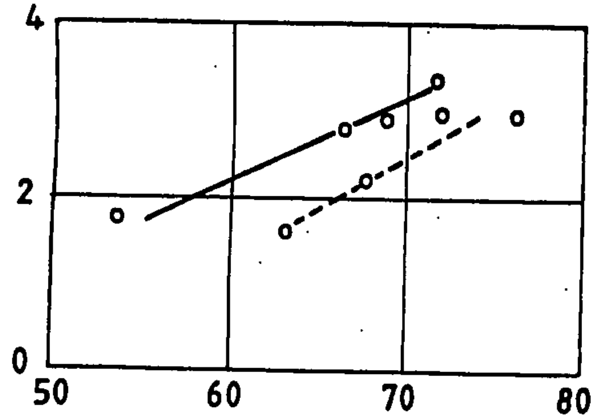

FIG. 2A

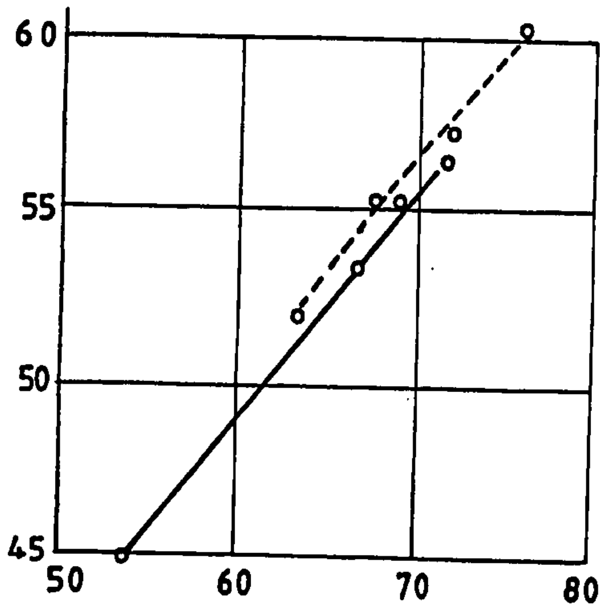

FIG. 2B

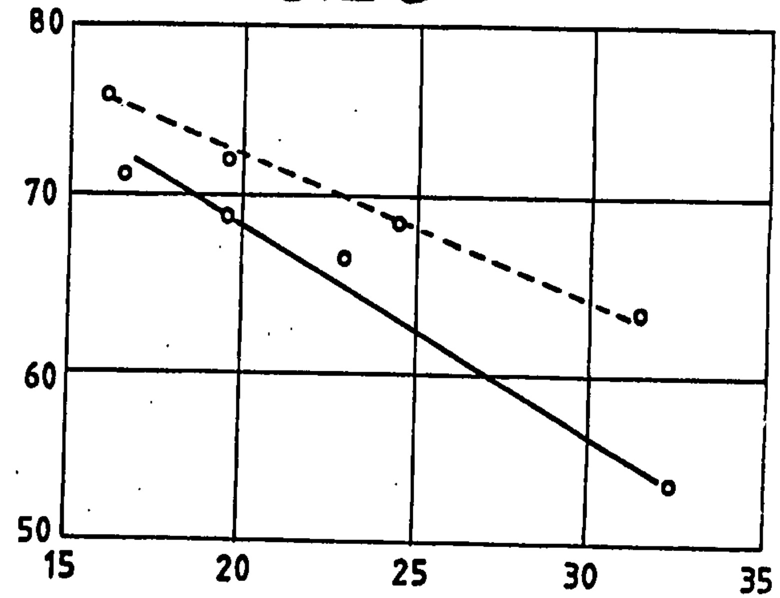

FIG. 2C

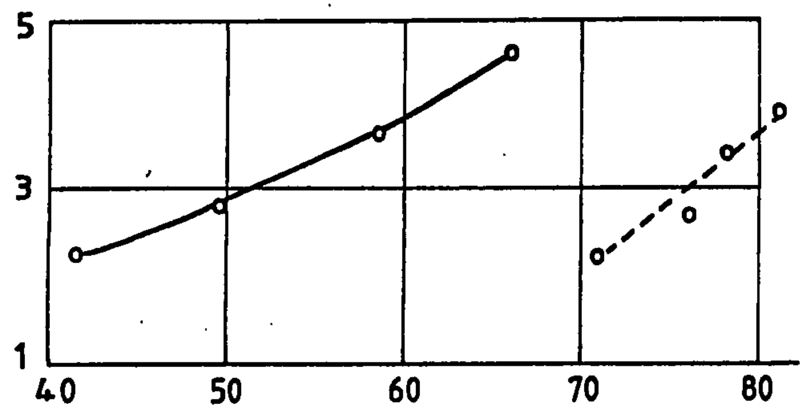

FIG. 3A

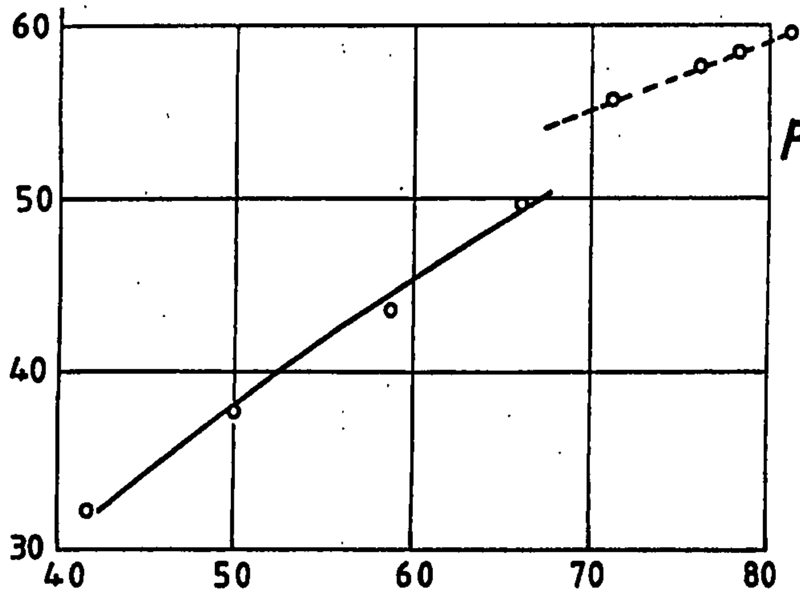

FIG.3B

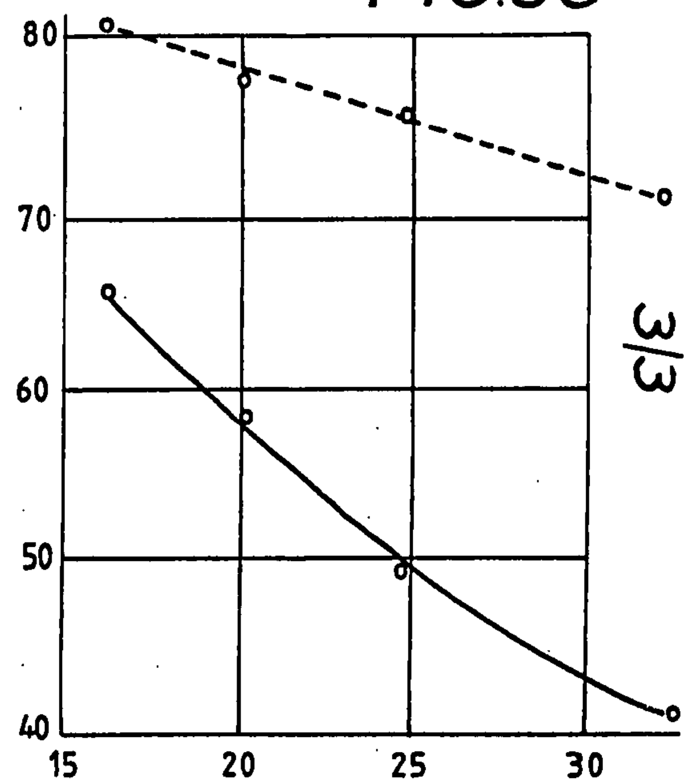

FIG.3C